
Trays For Growth Plugs, and Methods of Producing Them

Related Applications

This application claims the benefit of priority to United States Provisional Patent Application serial number 60/423,910, filed November 5, 2002.

Background of the Invention

Growth plugs are small independent segments of stabilized media which can house a variety of biological objects. The plugs typically serve as a medium for plant material, e.g., seeds, seedlings or cuttings, that will eventually be transplanted into a new environment. They can be used for propagation, germination, rooting, micro propagation, clonal propagation, and a variety of in vitro technologies, in addition to serving as a growth medium.

The most common use for these growth plugs is for starting young plants from seeds, cuttings or tissue culture, often followed by transplantation. The plugs usually consist of a block of growth medium, e.g., about 1 to 2 inches long and 1/2 to 1 inch in diameter. The growth media can include soil, peat, mulch, thatch, sand or any other organic, inorganic or gel substrate, depending on the environment most suited to the plant species. Typically, the plugs will house a cutting, seed or seedling; however, they can be fashioned to house larger growths, including saplings and immature shrubs.

The plugs provide a compact, economical and stable medium in which to house plant material for sale. Most decorative plants and flowers for home gardens are sold in growth plugs. The growth plugs are often housed in flats or trays constructed of thermoformed plastic. This lightweight plastic has become the material of choice because it is inexpensive to manufacture and easy to ship and store. Each flat is typically designed as a block with, for example, four to six cavities with tapered ends that hold the individual plugs. The bottom of each cavity is usually solid, with either a few small holes or one large hole to facilitate drainage from the housed plug. The sides of the cavity are smooth and non-fenestrated. The plugs are compressed into the cavities, and, depending on the hardness of the particular variety of plant, the flats may provide a sustainable environment for the cutting, seed or seedling for many weeks.

While the aforementioned flats often provide a sustainable environment for a cutting, seed or seedling, cuttings, seeds or seedlings grown in this environment tend to have a high rate of failure once transplanted to a permanent environment. The leading cause of failure by containerized plants is likely root deformity, in particular, root spiraling. Root spiraling is a condition where the root from the plant spirals around the bottom and/or sides of the plug. This condition is caused by a lack of air flow around the plug. Most roots will grow until they reach a soil-air interface. At a soil-air interface, the roots stop growing in a linear fashion, engaging instead in subsidiary growth in a branched pattern. The more natural root branching encourages stability in the ground when transplanted. Containerized roots never reach a soil-air interface and therefore the roots continuously grow in a spiraled pattern.

Traditional containers are produced utilizing thermoforming or injection molding. In injection molding, plastic material is heated until it reaches a molten state. Once sufficiently pliable, the plastic is forced into a mold that is complementary to the desired shape. As the plastic cools, it solidifies into an inflexible flat of the desired shape. Unfortunately, fashioning the flats out of molds can be time consuming and expensive. The rate of production is determined by the number of trays produced per cycle. Because the molds are typically reusable, the rate of production is also dependent on the amount of time required to cool the plastic to a sufficiently rigid state to enable release from the mold. In other words, the rate of cooling determines the rate at which the flats can be fabricated.

In contrast, extrusion molding eliminates a number of the problems associated with standard injection molding. In extrusion molding, plastic material is fed into a hopper. This plastic is carefully released into a chamber where the plastic is heated until molten. A reciprocating screw or a pressure differential continuously feeds the molten plastic through a die. The shape of the die is complementary to the desired flat. Once the plastic is fed through the die, and optionally allowed to cool for a period, it is sliced to form the desired object, which is then cooled, either through the use of cold water or cold air blowers. In extrusion molding the rate of production is dependent merely on the rate of feeding the plastic through the die. Extrusion molding is extremely advantageous when creating uniform shapes in a linear or block structure.

Summary of the Invention

One aspect of the present invention relates to a tray and its modifications for housing growth plugs in a stabilizing environment. A second aspect of the present invention relates to a method of forming trays for housing growth plugs, comprising the steps of extruding plastic through a die and cutting the extruded plastic periodically at an angle perpendicular to the direction of extrusion.

The present invention also relates to a tray for housing growth plugs, which tray comprises at least one open-ended cavity with a rib protruding into the cavity, where the cavity and rib are both constructed of a substantially rigid material, preferably plastic. The present invention also relates to a tray which consists of a number of open-ended cavities with ribs protruding into the cavity. The cavities are preferably of a uniform size and shape. A given wall of a cavity may be solid or perforated depending upon the use to which the tray will be put. The shape of the cavity can be any shape including, but not limited to, a polygon, a circle, oval or any non-angularly shaped object. The protruding ribs can be of any number or any size. They are located at intervals throughout the inner walls of the cavity and serve a dual purpose of allowing air to circulate within the cavity and to hold the growth plugs in the cavity. The ribs, which must be parallel to the direction of extrusion, can be positioned longitudinally, i.e., along the walls of the cavity, or latitudinally, i.e., perpendicular to the walls of the cavity. The ribs may extend fully along the walls of the cavity or may extend partially along the walls of the cavity.

The present invention also relates to a tray as described above, further comprising tabs configured at one end of the cavity and arranged to form a platform with a small aperture between the platform tabs as well as below the platform. The plug is configured to rest on the platform. In addition to providing an additional stabilizing feature for the growth plug, the platform allows air to pass under the plug when the tray is resting upright. This functionality increases air circulation to the plugs when the trays are resting upon each other or on a solid base. In a preferred embodiment, a rib positioned along the width of the platform protrudes into the cavity.

The present invention also relates to a method of forming a tray as described above. This method includes the steps of pouring plastic material into a hopper; selectively causing the plastic material from the hopper to enter into a heated chamber where the material is heated until

molten; causing the molten plastic to be passed through the die; and causing the extruded plastic material to enter into a cooling zone to solidify.

Brief Description of Figures

Figure 1 depicts a preferred embodiment of the trays of the present invention. The tray depicted comprises a linear series of cavities.

Figure 2 depicts one embodiment of the individual cavities of the tray. As can be observed from the photo, the cavity is open ended.

Figure 3 is a close up view of the cavities, showing the ribbing within the cavity in perspective view.

Figure 4 depicts a cavity with the modified platform.

Figure 5 depicts a preferred embodiment of the trays of the present invention. The tray depicted comprises a linear series of cavities comprising protrusions (“lands”) at one end.

Detailed Description of the Invention

Definitions

For convenience, certain terms employed in the specification, examples and amended claims are collected here.

The term “cavity” means a void or empty space within a solid body.

The term “growth plug” means an independent segment of stabilized growing media used to act as a housing for seeds or any plant material which needs to be in a consistent media prior to transplantation.

The term “stabilized media” or “stabilizing media” means an intervening environment through which something functions and thrives that is shaped into a fixed form which is not easily degraded. Stabilized media can include organic or inorganic material or a gel substrate.

The term “tray” means an utensil of the form of a flat board made of substantially rigid material designed for transporting soil plugs.

The term “ribbing” or “rib” means a ridge raised upon an object.

The term “complementary” means each of two parts that when combined create a whole.

The term “platform” means the surface or area on which anything stands.

Preferred Embodiments

Growth plugs are small independent segments of stabilized media which can house a variety of biological objects. These plugs serve as a temporary medium for goods that will eventually be transplanted into a new environment. They can be used for propagation, germination, rooting, micro propagation, clonal propagation, a variety of in-vitro technologies, or simply as a temporary growth medium.

A common use for growth plugs is for starting young plants from seeds or cuttings, usually in anticipation of transplantation. The plugs usually consist of a dense block of growth medium, e.g., about 1 to 2 inches long and 1/2 to 1 inch in diameter. The growth media may include soil, peat, mulch, thatch, sand or any other organic, inorganic or gel substrate depending on the environment most suited to the cutting, seed or seedling. Typically, the plugs will house a cutting, seed or seedling; however, they can be fashioned to house larger growths, including saplings and immature shrubs.

Most plants transplanted from traditional plugs display less vigor than their non-transplanted brethren. While a loss of vigor is anticipated in any transplantation, in many instances, even the hardiest of plants are unable to survive the transplantation without a considerable loss of vigor. The predominant cause of the loss of vigor associated with transplantation appears to be an unhealthy root structure in the transplanted plant.

Research into the development of new containers for housing growth plugs may hold the answer to increasing the vigor of transplanted plants. When roots reach the soil-air interface, they naturally prune themselves, effectively inhibiting root elongation; moreover, the roots subsequently engage in root branching, which forms interlaced root segments which innervate the growth medium. Plugs which have been “air-pruned” tend to exhibit less root mass near the root ball. The branched root system which forms in air-pruned plugs provides greater stability for the transplanted plant. In addition, because the branched root system stays confined within the growth medium, it is not as vulnerable to temperature extremes or transplant shock. Further, as the bulk of the roots do not come in contact with the plastic, the plugs are much easier to remove from their trays. The result is a transplanted plant with greater vigor than more traditionally containerized plants.

While the aforementioned flats can provide a sustainable environment for these cuttings, seeds or seedlings, cuttings, seeds or seedlings grown in this environment tend to have a high rate of failure once transplanted to a permanent environment. It is believed that the leading cause of failure by containerized plants is root deformity, in particular, root spiraling. Root spiraling is a condition where the root from the plant spirals around the bottom and sides of the plug. This is caused by a lack of air flow around the plug. Most roots will grow until they reach a soil-air interface. At the soil-air interface, the root stops growing in a linear fashion and instead engages in subsidiary growth in a branched pattern. The more natural root branching encourages stability in the ground when transplanted.

Unfortunately, traditional containers for the growth plugs encourage root spiraling, facilitating damage to the plant at transplantation by preventing an adequate soil-air interface. The solid base and sides found in traditional containers prevent air flow to any part of the plug except the top of the plug. Furthermore, the tapered base of the traditional container compresses the root base of the plug. In tapered containers, the plugs are dislodged either by applying force, e.g., forced air or a rod, to the plug's underside, or by pulling on the plant material itself. In addition, the spiraled roots at the bottom of the containerized plug tend to adhere to the side wall of the containers, adding to the difficulty in removing the plugs.

The present invention describes a tray with a series of open-ended uniform cavities. The cavities are uniform in size and shape and are non-tapered. In a preferred embodiment the cavities are lined with protruding ribs positioned longitudinally along the cavity walls.

This type of tray is an improvement over the prior art because of a number of features. Unlike other trays, the present invention relates to a non-tapered cavity. This is functionally important in protecting the growth plug from damage upon removal and promotes air circulation along the bottom of the plug, thereby encouraging greater media in which the roots may thrive.

In addition, the present invention describes an open-ended cavity. Unlike the prior art which describes closed bottom cavities or cavities that have very small apertures at the bottom, the present invention describes an evenly sized open-ended cavity. The open-ended nature of the cavity of the trays of the present invention facilitates removal of the plug. In contrast, plugs in tapered cavities may only be removed by applying force to underside of the plug or by pulling the plug via the plant. Both methods of removal risk damage to the plugs and to the plants. With

an open-ended cavity, the risk of damage to the plant material when removing the plug is greatly reduced. In addition, the open-ended nature facilitates greater air circulation around the plug preventing root spiraling.

The present invention also describes ribs which protrude into the opening of the cavity. These ribs serve a dual function. First the ribs provide for air circulation around the plug. Second the ribs serve to retain the plugs within the cavities. The ribs protrude from the walls of the cavity with a sufficient width that even as the plug changes in size due to changes in moisture it nevertheless is retained in the cavity by the ribs.

In a preferred embodiment the present invention also describes platforms which are cut out of the walls of the cavity. This platform is situated $1/8$ or $1/4$ of the distance from one end of the cavity. The platforms are configured such that they face into the cavity and create an aperture between the platforms and below the platform. The platforms have ribs that run the width of the platform and protrude into the cavity.

Trays

One aspect of the present invention is a tray with open cavities uniformly distributed along a linear strip. (Figure 1) In a preferred embodiment the number of cavities along the strip is twenty-six with each cavity designed as a square in the horizontal plane and a rectangle in the vertical plane. (Figure 1 and Figure 2) In this preferred embodiment each cavity has evenly spaced vertical ribbing which travels along the length of the cavity. (Figure 3) However, in other embodiments the ribbing could extend only partially down the inner wall of the cavity. In the preferred embodiment the ribbing is in the vertical plane of the cavity. The combination of the open cavities and the vertical ribbing insures that the plug is surrounded by adequate air flow to encourage "air pruning" thereby preventing the damage resultant from rampant root spiraling. The ribbing in particular, also serves to retain the plugs in the cavity as the size of the plug changes in response to moisture content. The open cavity serves to insure safe removal of the plug from the tray. For example, the parallel walls of the cavities of the trays of the present invention allow the use of plugs with a base of greater area, relative to the area of the plug's base when tapered cavities are used, thereby decreasing the pressure (force/area) experienced by the base of the plug when the plug is ejected by the application of force to said base. In certain

embodiments, a given wall of a cavity may be solid or perforated depending upon the use to which the tray will be put.

In another preferred embodiment at one end of the cavity, about an $1/8^{\text{th}}$ of the way up from the bottom of the cavity on two non-adjacent walls a middle segment of identical lengths is folded into the cavity thereby creating two parallel platforms and creating either an “H” shaped or “I” shaped aperture at the bottom of the cavity. (Figure 4) These platforms can be designed to form any shaped aperture at the bottom of the cavity. The platforms must merely be numerous enough for the plug to evenly rest on it and still provide for a sufficient aperture below the platform to allow for adequate air flow.

These platforms are designed for two purposes. First, the platforms provide a resting place for the plugs thereby preventing them from accidentally dislodging. Second, the platforms enable continuous airflow when the trays are placed on the growing bench. The platforms also exhibit ribs along the width of the platform. These ribs encourage air circulation even when the plug is sitting on top of the platform.

Another aspect of the present invention is a method of producing the trays through plastic extrusion. Most plastic trays are produced using injection molding or thermoforming. In injection molding manufacturing, plastic material is placed in a hopper and is subsequently fed into a heated injection unit. A reciprocating screw pushes the plastic through a long heated chamber. At the end of the chamber is a nozzle which pushes the fluid plastic into a cold mold. As soon as the plastic cools to a solid state, the mold opens and the plastic is ejected.

Injection molding poses a number of manufacturing problems. In particular, the rate of production of goods produced in injection molding is dependent on maintaining the plastic in an extremely warm environment prior to placing it in a mold. Any decrease in temperature prior to insertion in the mold will cause the plastic to harden to an inflexible state. In addition, the rate of production is dependent on the rate of cooling of the plastic and the number of trays produced per cycle. As a result, injection molding is not the ideal method of manufacturing for uniform simple objects in a series.

Extrusion molding, on the other hand, may provide a solution. In extrusion molding, dry plastic is loaded into a hopper which feeds the plastic through a long heating chamber. The molten plastic is forced out through a die which is shaped to be complementary to the desired

finished product. In certain embodiments, as the product is extruded, it is measured until it reaches the desired height. Once it does, it is sliced at an angle perpendicular to the direction of extrusion. The plastic is then allowed to cool and set into the desired shape. In alternative embodiments, a given length of product is extruded, followed by cutting the given length into a plurality of pieces of the desired dimensions.

Extrusion molding solves a number of the problems of injection molding. In particular, with the extrusion process, the rate of manufacturing is determined by the die as opposed to the mold. As a result from one die many sequential copies can be made increasing the rate of production as compared to an injection mold process where the rate of production is dependent on the number of molds filled.

Method of Making Trays

According to the present invention, a method of extruding plastic material into multiple compartment trays includes providing an extrusion die with the complementary die to the shape of the compartment trays. This die can have the shape of any polygon, circle, oval, or any non-angular irregular shape. A melt stream of plastic material is forced either through the increase or decrease of pressure or through the use of a mechanical conveyor system into the die. The molten plastic material is passed through the die with extrusion of an object in the form complementary to the extrusion die.

The melt stream may flow continuously through the die, optionally allowed to cool for a period; a slicing instrumentality will then cut the extrude plastic. The cooling phase rapidly decreases the temperature of the extruded object, thereby solidifying the plastic material into the desired shape. The cooling phase can be created through the use of cold air blowers, cold water, or frozen carbon dioxide.

Plastics which can be extruded include, acetal (both copolymer and homopolymer), acrylic, acrylonitrile butadiene-styrene, cellulose acetate butyrate, copolyester (PETG), ethylene vinyl acetate (EVA), polycarbonate, polyester, polyetherimide, polyethylene (HDPE), polyethylene (LDPE), polyphenylene, polypropylene (copolymer and homopolymer), polystyrene (crystal), polystyrene (high impact), polysulfone, polyurethane (ester and ether), polyvinyl chloride (rigid PVC), polyvinyl chloride (specially blended flexible pvc), thermoplastic rubber, and any other extrudable plastic.

Incorporation by Reference

All of the patents and publications cited herein are hereby incorporated by reference.

Equivalents

Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed by the following claims.